National Aeronautics and Space Administration

Coronagraph Options for Exoplanet Finding and Characterization

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Project Objective

FINDING LIFE BEYOND OUR SUN

- Coronagraphy uses direct imaging to find exoplanets and characterize their spectra and orbits in the visible.
- Exoplanet size capability scaled to mission cost: Jupiters, Super-Earths, Earths
- Ongoing studies will identify most promising coronagraph design (science, cost, risk, technology) for allocated budget ranges and launch dates.

Recent Results

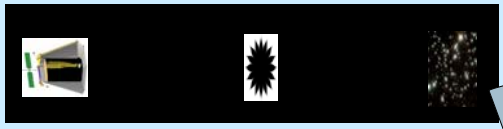
- ROSES Mission Concept Study proposals for various probe & flagship coronagraph concepts: Internal Occulters, External Occulter, Hybrid
- High Contrast Imaging Testbed (HCIT) demonstrates starlight suppression technology currently exists for:
  - Jupiters in 6% broadband light, with periodic wavefront resets
  - Earths in monochromatic light, with aggressive WF stability requiremts[1]
- FB1 (Flight Baseline) Flagship mission study establishes desired science, system requirements, technology and analyses for coronagraph mission design[2]

Project Description

Astrophysics Strategic Mission Concept Studies
6 Coronagraphs out of 19 Selected Concepts = 32%

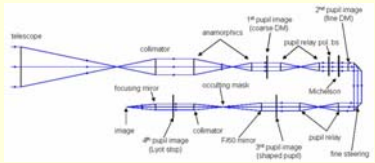
Name	Instrument	Size	PI Affiliation	Category
PECO Pupil-mapping Exoplanet Coronagraph Observer	PIAA	1.4m Telescope Medium Class	Olivier Guyon Univ of Arizona	Internal Coronagraph
ACCESS	Band-Limited, PIAA, Shaped-Pupil, 4QPM	1.5m Telescope Medium Class	John Trauger JPL	
XPC eXosolar Planet Characterizn	Hybrid: Internal / External	4m Flagship w/ 30m Shade	David Spergel Princeton	
NWO New Worlds Observer	External Occulter	4m Flagship w/ 25m/50m Shade	Webster Cash - Univ of Colorado	External Occulter
DAVInCI	Dilute Aperture Visible Nuller	4x1.2m Flagship	Mike Shao JPL	Internal Coronagraph / Interferometer
EPIC	Visible Nuller	Medium Class	Mark Clampin - GSFC	

External Occulter[6]

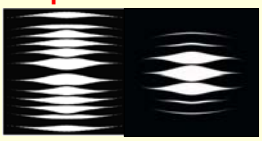


Broad band, uses standard telescope, good inner working angle, large deployable structure w/ mm edge accuracy, challenging alignment, limited mobility, very few revisits

Internal Coronagraphs

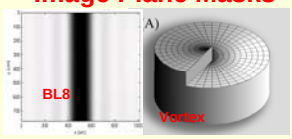


Pupil Plane Masks[3]



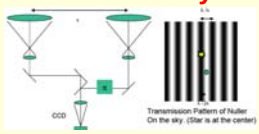
Easy to manufacture, easy to achromatize, simplest design, low throughput, large IWA.

Image Plane Masks[1]



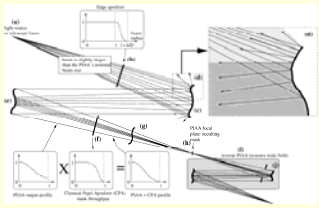
Band-Limited Mask has best performance so far, good aberration rejection, hard to achromatize, moderate throughput, most mature

Shearing Nulling Interferometry[5]



No optics in image plane, most complicated to implement, throughput and IWA similar to band-limited mask

Pupil Remapping (PIAA)[4]



Potentially closest to 'ideal'; high throughput, small IWA & PM, challenging optics, unknown WFC issues.

Hybrid Coronagraph[7]

Reduces aggressive WF stability requirements on internal coronagraph, provides better agility, broadband performance, reduces risk, sequential 2-phase mission

Benefits to NASA and JPL

"Direct imaging may be the only means for establishing the habitability or signs of life on any exoplanet" [8]

Publications

1. Trauger and Traub, *Nature*, 446(7137) (2007)
2. Levine et al., TPF-C Science and Technology Definition Team (STDT) Report (2006)
3. Kasdin et al. *Applied Optics*, 44,7 (2005)
4. Guyon et al., *ApJ*, 644, 1246 (2006)
5. Shao et al., *Comptes Rendus-Physique*, 2007
6. Cash, *Nature* (2006)
7. Traub & Kasdin, Exoplanet Task Force White Paper (2007)
8. Astronomy and Astrophysics Advisory Committee, *"Worlds Beyond: Report of the ExoPlanet Task Force"*, Draft, Feb 2007